

E. Compatibilization/Compounding Evaluation of Recovered Polymers

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Participants:

This project is conducted as part of the CRADA between Argonne, USCAR's Vehicle Recycling Partnership and the American Plastics Council

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Objective

- Evaluate the market opportunity of polymers recovered from shredder residue.
- Identify limitations to the re-use of the materials as recovered and determine the need for postprocessing technology to upgrade the recovered materials to meet the requirements of the market.

Approach

- Specify standard protocols for material testing, content characterization, and performance properties.

Accomplishments

- Established a test protocol for material testing, content characterization and physical properties testing of polymeric materials.
- Issued a contract to Midland Compounding to evaluate the properties of polymers that are recovered as part of the technology demonstrations that are being conducted under the project "Postshred Materials Recovery Technology Development and Demonstration."
- Initiated physical properties testing of recovered samples.

Future Direction

- Continue physical properties testing of recovered polymers.
 - Evaluate the market potential for clean mixed plastics streams recovered from shredder residue.
 - Establish a database of properties of recovered polymers vis-à-vis general purpose virgin polymers.
 - Identify candidate automotive applications for recovered polymers.
 - Conduct mold trials using recovered polymers.
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Summary

The objectives of this project are (1) to characterize the properties of potentially recyclable automotive materials and (2) to confirm the technical and economic feasibility of using those materials in value-added applications.

The project will initially focus on establishing the properties of polymeric materials that are recovered as part of the Post-Shred Materials Recovery Technology Development and Demonstration project.

Regardless of the effectiveness of any automotive materials recovery technology, the materials that will be recovered will be on average 10 to 15 years old. In this project, the performance properties of recovered polymers will be compared vis-à-vis new or virgin materials to establish a database of the properties of recovered automotive polymers. At present, there are few data concerning the physical properties of polymers recovered from postconsumer durable goods. Absent such data, it is unlikely that sustainable applications for recycled materials will be either identified or developed.

Blending and compounding tests will be done, as required, to achieve desired performance properties of the recovered materials for target applications. Mold trials may also be conducted to confirm the technical and economic feasibility of using recycled polymers in specific applications.

Physical properties testing is conducted by Midland Compounding, Inc. Midland will also run composition testing for comparison with compositional analysis done on recovered materials by Argonne.

Three other companies, Collins and Aikman Corporation, Enviro-Plas Corporation, and Mayco Plastics, Inc., have agreed to evaluate, compound,

and run mold trials using recovered materials subject to the physical properties of the recovered materials.

Polymer Physical Properties and Materials Composition Analysis

Typically, 10-lb samples of recovered materials are utilized to define physical properties and to characterize the composition of the material.

To quantify physical properties, the sample is extruded on a single-screw extruder, melt screened through a 40-mesh screen, molded into American Society for Testing and Materials (ASTM) test bars and plaques, and tested. The molded parts and a random selection of regrind chips from each sample are evaluated for material identification on a Bruker P/ID 28 IR machine.

Physical properties that are measured for each sample include the following:

- melt flow rate,
- Izod impact,
- flexural modulus,
- tensile strength at yield,
- tensile strength at rupture,
- elongation at rupture,
- deflection temperature,
- Gardner impact, and
- specific gravity.

Physical properties of the high-impact polystyrene (HIPS) and the acrylonitrile-butadienestyrene (ABS) materials recovered during the shakedown tests of the Argonne froth-flotation process are summarized in Table 1. The shakedown trials were conducted using postconsumer shredded electronics and appliances scrap, not plastics from a typical automotive shredding

Table 1. Physical properties of HIPS and ABS recovered during Argonne froth-flotation shakedown trials

Properties	HIPS 1	HIPS 2	ABS
Melt flow rate, g/10 min, 200°C, 5 kg	5.4	5.5	5.2
Izod impact, ft-lb/in., 73°F	1.6	1.6	1.6
Flex modulus 1% secant, psi	248,662	262,939	341,543
Tensile strength at yield, psi	3,068	3,091	5,242
Tensile strength at rupture, psi	3,082	3,137	5,035
Elongation at rupture, %	38	41	33
Deflection temperature under load, 264 psi, °F	147	153	165
Gardner impact, 73°F, in.-lb	12	20	4
Specific gravity, g/cm ³	1.05	1.05	1.08

operation. (See the Annual Report, “Postshred Materials Recovery Technology Development and Demonstration, see 6.C.)

A comparison of the physical properties of the recovered HIPS to various primary or “virgin” grades of HIPS indicates that the properties of the recovered postconsumer material are within the ranges of the “virgin” grades (Table 2).

Polymer Physical Properties Database

A physical properties database is being compiled to provide comparison of the physical properties of the recovered polymers vis-à-vis general purpose virgin polymers. The Vehicle Recycling Partnership had previously compiled physical properties data on selected polymers that

were recovered during the U.S. Field Trials. These materials were recovered by disassembly. These data will also be included in the database to

provide a comparison between the physical properties of materials recovered by disassembly relative to materials that are recovered from postshred operations.

General purpose physical properties have been compiled from the literature for the following plastics:

- ABS,
- nylon (6 cast, 6/6 extruded, 30% glass filled),
- PPO (unfilled, 30% glass filled),
- polycarbonate,
- polyethylene (LDPE, HDPE, UHMW),
- polypropylene,
- polystyrene (general purpose, high impact), and
- polyvinyl chloride (PVC).

Other polymer specifications may be added to the database as appropriate.

Table 2. Comparison of “recycled” and “virgin” grades of HIPS

Properties	HIPS 1	HIPS (natural)	Dow 484 HIPS (natural)
Generic material description	As received	Range	Typical HIPS
MFR, g/10 min, 200°C, 5 kg	5.7	2–14	2.8
Izod impact, ft-lb/in., 73°F	1.8	1–4	2.1
Flex modulus, 1% secant, psi	275,927	240,000–430,000	277,000
Tensile strength at yield, psi	2,660	2200–4500	2,800
Tensile strength at rupture, psi	3,033	2100–4500	3,500
Elongation at rupture, %	48	25–70	52
DTUL, 264 psi, °F	178	157–199	165
Gardner impact, 73°F, in.-lb	14	10–330	160
SG, g/cm ³	1.053	1.04	1.04

